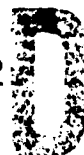AD-A253 092

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Developing Cost-Effectiveness Guidelines for Managing Personnel Resources in a Total Force Context

Executive Summary

Adele R. Palmer, C. Peter Rydell

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Prepared for the
Assistant Secretary of Defense
(Force Management and Personnel)

RAND

PREFACE

This report summarizes recent research on modeling Department of Defense manpower decisions in a "total force" management context—i.e., in a context that simultaneously recognizes the roles of the active, reserve, and civilian work forces in achieving both peacetime and potential wartime operating goals. The modeling approach was introduced in a previous report: Adele R. Palmer and C. Peter Rydell, *An Integrative Modeling Approach for Managing the Total Defense Labor Force*, The RAND Corporation, R-3756-OSD/AF, December 1989. The research herein extends the original model in several ways—most notably by allowing for rotation, retraining, and mobilization programs—and shows how the modeling approach can support the development of general manpower management guidelines. The findings should be of interest to the defense manpower policy community in general. Our detailed analysis is in a companion report: C. Peter Rydell, Adele R. Palmer, and David J. Osbaldeston, *Developing Cost-Effectiveness Guidelines for Managing Personnel Resources in a Total Force Context*, The RAND Corporation, R-4005/1-FMP, 1991.

ACKNOWLEDGMENTS

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I. INTRODUCTION

Over half of the Department of Defense (DoD) budget is attributable to the pay and support of its work force—the active and reserve forces, civil servants, and private sector contractors providing direct labor services. This work force supplies manpower for peacetime operations and an inventory of human resources for potential wartime operations. In a period of fiscal austerity, managing this labor force to meet defense capability goals while minimizing costs is a major policy issue.

In previous research, we developed a Total Force Management (TFM) modeling approach for determining the most cost-effective combination of active, reserve, and civilian manpower consistent with specified wartime and peacetime defense objectives. The TFM approach differs from conventional methods of analyzing manning decisions—which compare active and reserve manning for wartime activities or active and civilian manning for peacetime activities—by recognizing that most defense activities would be conducted in both wartime and peacetime and that active duty military personnel are readily available to meet labor demands in both those environments. An earlier TFM report (Palmer and Rydell, 1989) showed that, under reasonable cost and performance conditions, active duty personnel can substitute for a combination of civilians doing peacetime work and reserves doing wartime work and cost less than the combination of replaced personnel. The implication is that current defense guidelines encour-aging use of civilian manpower whenever possible might not be cost-effective.

The purposes of the current research, which is more fully documented in Rydell, Palmer, and Osbaldeston (1991), were the following:

- To extend the earlier illustrative model to address a wider variety of issues.
- To show how the modeling approach can support general manpower management guidelines.
- To assess the potential for improving comprehensive personnel force management through the application of TFM concepts and principles.

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II. HIGHLIGHTS

The most significant extensions to our earlier work provide for personnel flows among defense activities. The original TFM model dealt with an individual Part of Force (POF)—a single occupational category within a single defense activity. In contrast, newly extended models explicitly account for the trainee and instructor time used in schoolhouse training and track potential movements of personnel among POFs under these types of programs:

- Retraining programs that enable personnel to change occupational categories during their careers;
- Mobilization programs that may assign personnel to one POF for peacetime but would mobilize them with a different POF in event of war (and provide training as needed to supply required skills); and
- Rotation programs that regularly relocate personnel among POFs in order to maintain manpower supplies to overseas locations without requiring individuals to remain there permanently.

Rydell, Palmer, and Osbaldeston (1991) also extend our previous findings by showing that using active personnel can save costs over very wide ranges of cost and effectiveness values. Furthermore, the report demonstrates that it is not necessary to be able to replace both civilians and reserves in a single activity in order for manning by actives to be cost-effective. With programs that enable personnel to work in different POFs at different times, actives can replace civilians in some activities and replace reserves in others—and save money overall.

To evaluate the potential for improving defense manpower management, the report compares and contrasts two different management principles. One effectively aims to use the smallest active force consistent with meeting wartime needs, which is a basic thrust of existing defense guidelines, while the other aims to use the least costly combination of personnel consistent with meeting all work-force needs. Both principles must be applied with due regard to maintaining personnel force capabilities over time and with due recognition of various legal and institutional constraints. Even so, we show that the two principles imply different manning choices under conditions that can reasonably be expected to appear in practice, and we suggest that

applying the cost-minimization principle can potentially save significant amounts of money.

For policy screening and oversight purposes, cost-minimization guidelines can be developed and applied much as current ones are—by answering a series of yes-or-no questions that assign a preliminary manning strategy to a specific case under consideration. As under current guidance, the preliminary strategy is a candidate policy that can then be evaluated in terms of the broader range of issues that properly influence manning decisions.

For developing detailed manning profiles for specific force units or functions, however, we recommend developing a full-scale optimization methodology. Ideally, this methodology should go beyond existing simplified models in two respects. First, the models should choose among specified manning alternatives for force units and functions (e.g., squadrons, battalions, depots) rather than assume simple linear rates of manpower substitution. Second, the models should recognize the dynamic processes of personnel inventory management and force-unit activation and deactivation. We do not believe these extensions would significantly alter the basic findings of our models, but we suggest below that such extended models would—for the first time—fully integrate the perspectives of DoD manpower and personnel managers.

In the remainder of this report, we:

- Describe the TFM modeling approach.
- Explain how manning guidelines can be developed from TFM models.
- Summarize our findings with respect to dual use (retraining, mobilization, and rotation) programs.
- Consider whether cost-minimization guidelines could save significant amounts of money.
- Show that the guidelines can be applied despite considerable uncertainty about particular parameter values (especially personnel effectiveness).
- Relate the current TFM modeling techniques to existing manpower and personnel modeling.

III. THE TFM MODELING APPROACH

TFM models represent a distinctive approach to analyzing manpower and personnel management. The following discussion clarifies important features of the approach and the terminology we use to describe it.

PART OF FORCE

The DoD uses various terminologies to describe its productive activities. Deployable activities are often described in terms of organizational structure—a squadron, battalion, command, etc. Meanwhile, nondeployable activities—depot supply and maintenance, accounting, budget preparation, etc.—are often described as "functions." Because we use a common modeling approach for all types of productive activities, we use the general term "Part of Force" to refer to them.

Although we have designed TFM models that ad `ress the mix of labor and nonlabor resources a POF may use, the models used for guidelines analysis deal only with personnel resources. For modeling purposes, therefore, a POF is defined by four characteristics: POF output goals, the supplies of personnel to the POF, the contributions those personnel can make to the POF's goals, and the cost of personnel.

Output Goals

A POF may be called upon to perform duties or functions in alternative defense environments. Current TFM models treat each POF as having goals in these three environments:

- The "surge" environment of initial hostilities or immediate response to a military contingency.[1]
- The "sustainment" environment of full mobilization—with reserves called to full-time duty—to counter a continuing military threat.

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[1]There is no generally accepted term for the environment described here, and the word "surge" sometimes has other meanings in defense use. Since we use "surge" in our other TFM reports, we preserve that term here, hoping that does not create confusion for readers familiar with the term's other meanings.

- The "peacetime" environment during which the DoD carries out activities under benign conditions.

The wartime environments do not necessarily require deployment of a particular POF. During surge, for example, some POFs (e.g., combat battalions) might be expected to deploy while others (e.g., maintenance depots) might be expected to step up activities without deploying to a new location.

A major determinant of a POF's manning, both in practice and in TFM models, is constituted by the goals for output in the three defense environments. The peacetime goal includes both peacetime defense operations (such as intelligence gathering) and activities that support preparations for wartime (such as recruiting personnel, procuring equipment, and performing training exercises and maneuvers).[2] Wartime goals reflect operational plans for carrying out or supporting military missions.

TFM goals are analogous to the wartime and peacetime manpower requirements the services specify for various activities—with two exceptions. One is that TFM goals are expressed in standardized labor units—a notional quantity of labor services—that can be met by alternative kinds of personnel, depending on their availability and effectiveness in alternative environments. The other is that the model measures only the portion of wartime goals that would have to be met by personnel already on the defense payroll during peacetime.[3]

Output goals are POF-specific. For example, a POF in the tactical forces might have a sustainment goal much greater than its surge or peacetime goals, while a strategic missile unit would presumably have a surge goal that is much greater than its sustainment goal. Though it is difficult to identify a defense activity that would cease operations entirely in any environment, one could be modeled by setting one or more of the goals to zero.

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[2]However, existing models do not assume that the peacetime output goal depends on the type of personnel in the POF. Thus, the level of peacetime training is assumed to be equal for a POF manned by actives or reserves. This assumption does not affect the model's general implications but should be relaxed in operational models to render a correct cost accounting.

[3]In practice, most wartime scenarios assume that additional personnel, such as new civilian hires and retired military personnel, could be mobilized from the civilian sector to supplement essential support such as medical, supply, and mess services. The TFM models simply set aside the portion of wartime work that could be performed by such personnel.

Personnel Supplies

The personnel classifications used in the TFM models are:

1. "Actives"—military personnel on full-time active duty throughout the year.[4]
2. "Reserves" (also "drill reserves")—military personnel on active duty for just a portion of each peacetime year, primarily for training.
3. "Civilians"—nonmilitary personnel employed full-time during peacetime.[5]

Within each classification, the models distinguish between "juniors" and "seniors." The latter are experienced workers, while the former are still acquiring skills and therefore may be relatively less effective (and perhaps less available) in POF work.[6] The models also account for prior-service reserve accessions by providing for "crossflows" from the junior active to senior reserve category.

For each personnel classification, the overall supply of personnel to a POF is determined by the number of personnel accessions to support the POF, the average number of years an accession spends in the junior category, the probability that the junior will be retained (or crossflow) to become a senior, and the average number of years spent in the senior category. Our numerical illustrations use actual DoD-wide statistics for fiscal year 1987 to estimate these parameters.

The models are designed to support general management guidelines and defense planning-phase activities rather than specific year-to-year personnel programs. Therefore, the models characterize steady-state inventories—inventories in which numbers of accessions and retention rates are held constant over time.

Personnel Contributions

We evaluate the contributions personnel can make to a POF's output on a "life-cycle" basis—i.e., over the expected number of junior

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[4]This classification currently includes reserve component personnel on full-time active duty (i.e., Active Guard-Reserve personnel).

[5]In principle, this classification includes civilians working for the DoD under service contracts with private firms, but the cost values used in our illustration are estimated from data on civil service personnel.

[6]For our numerical illustrations, we define juniors as personnel with up to four years of defense experience—but other definitions could be used and the models could easily be expanded to include additional levels of seniority.

and senior years the individual will be in the inventory.[7] Life-cycle contributions differ among active, reserve, crossflow, and civilian accessions.

In addition to the number of man-years in a life cycle, two factors determine contributions to output. One is availability—the amount of time spent in POF duties per inventory man-year. It is low for reserves in peacetime and may be low for juniors in all classifications because they spend some time in schoolhouse training. The other factor is effectiveness—the amount of output supplied per full-time-equivalent duty year. For our numerical illustrations, we use hypothetical effectiveness parameters that differ by seniority and personnel classification.

Availability parameters are largely determined by defense policy. For example, if policy does not permit civilians to relocate with a unit that deploys in wartime, then the civilian availability for wartime deployment would be zero even if civilians are ready and willing to deploy; similarly, if policy dictates that a particular activity (e.g., classified communications operations) must be manned by military personnel, then civilian availability is zero. Personnel with zero availability in an environment cannot contribute to output in that environment.

Previous TFM models assumed that only actives could produce output in more than one environment. In contrast, our extended models assume that reserves can make a (limited) contribution to peacetime and surge output, and we have now modeled nondeployable POFs where civilians can contribute to wartime output.

Costs

Although we have developed TFM models that use equipment as well as personnel to produce defense output, the models used in our guidelines analysis deal only with labor resources and hence recognize only costs pertaining to personnel. As with labor contributions, the costs are calculated over an entire life cycle. The elements of labor-related costs are:

- Induction costs: nonrecurring costs for recruitment and individual training, measured per accession. (TFM models explicitly account for the additional senior personnel required to provide instructional and other induction services to new accessions.)

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[7]In a steady-state model, the contribution over a life cycle equals the inventory's annual contribution per accession.

- Pay and benefits costs incurred on an annual basis, including retirement accruals.

The models deal only with costs incurred during peacetime. They focus therefore on the costs of creating and maintaining defense capability rather than on the costs of using that capability in particular conflicts.

SINGLE- VS. MULTI-POF MODELS

Some TFM models deal with only a single POF. These models behave as though personnel entering a POF remain there throughout their careers. However, "dual use" models designed to consider retraining, rotation, and mobilization programs must encompass multiple POFs because personnel supply labor to more than one POF at different times or in different environments.[8]

The POFs in a dual use model do not necessarily have the same goal structures (i.e., combinations of surge, sustainment, and peacetime goals) and may also differ in other parameters, such as availability factors. In particular, we have examined pairs of POFs in which one is nondeployable (so that civilians are available in wartime) and the other is deployable (and can use civilians only in peacetime).

OPTIMIZATION AND POLICY COMPARISONS

Existing TFM models are linear optimization models. They select personnel management actions (primarily numbers of active, reserve, and/or civilian accessions), subject to the constraint that aggregate labor contributions are at least sufficient to meet the POF's goals.

Alternative combinations of personnel can meet the goals, so the models optimize by selecting a combination that meets a specified objective. Since one of the purposes of this study is to explore how a change in management guidance might affect defense manning and costs, we compare alternative objectives:

- The Minimal Active Force (MAF) rule is based on existing guidance: DoD Instruction 1100.4[9] indicates that civilians

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[8]The "dual use" models all include a dual-training variable that allows the programs to provide additional training—at additional cost—to prepare personnel for their alternative POF assignments. If a program does not provide additional training, the value of the dual-training cost is set to zero.

[9]Department of Defense Instruction 1100.4, Washington, D.C., August 1954.

should be used unless military personnel are required for such reasons as "law, training, security, discipline, rotation, or combat readiness"; informal guidance indicates that when military personnel are required, reserves should be used whenever they can do the job and cost less than actives. TFM models reflect this guidance when they meet POF goals by minimizing military (active and reserve) personnel costs.[10]

- The Cost-Minimizing Active Force (CAF) rule: This alternative meets POF goals by minimizing overall personnel costs—including costs for civilians as well as military personnel.

All of the policy comparisons hold legal, institutional, programmatic, performance, and other constraints constant. For example, if military personnel in an overseas POF are subject to a rotation program with a particular tour length, we assume that the rotation pattern would be maintained under new guidance. Similarly, a change in guidance would not alter existing policy that precludes using civilians to man strategic missile crews.

Compared with existing guidance, the CAF objective can never increase aggregate costs, but it might reduce them. In all cases where cost minimization saves money, it does so by using an active force larger than the MAF—by using "extra actives" to replace some combination of the reserves and civilians that would be used under existing policy. Therefore, the difference between the MAF and CAF active-force sizes is a convenient indicator of whether and how cost-minimization would alter manning outcomes.

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[10]If civilian labor contributions are positive for all environments, this objective implies that only civilians should be used because that reduces military personnel costs to zero. However, if civilians are not available or effective in one or more environments (as might be true in a deployable POF), then the model will use the least costly combination of actives and reserves that can satisfy the unmet goal(s). Using cost parameters that make reserves less costly than actives, the model recommends using reserves if possible. Like existing guidance, this version of the model recommends the smallest active inventory consistent with defense requirements.

IV. DEVELOPING MANNING GUIDELINES

Manning guidelines establish the basic principles for selecting a personnel mix and identify circumstances or conditions to be taken into account in the selection process. They do not dictate particular manning outcomes (i.e., numbers of personnel by category), but they suggest a reasoning process that would lead to a *preliminary* manning strategy for further consideration.

TFM models can derive manning strategies directly (under either existing guidance or a cost-minimization policy). However, we have also developed a technique that uses basic calculations to derive a strategy for manning individual POFs. These techniques would be particu-larly suitable for general policy oversight purposes.

A SIMPLIFIED ILLUSTRATION

To explain how the TFM models support manning guidelines, let us use an oversimplified example that can be solved intuitively. Throughout this example, we deal with a single POF in which only actives can contribute to output in all environments, reserves can contribute only during sustainment, and civilians can contribute only during peacetime.

Obviously, this POF must use at least enough actives to meet the surge goal. Those actives also supply some peacetime and sustainment labor in the same POF. Whether other personnel will also be used depends on the POF's goal structure. Therefore, let us consider the four cases that encompass all possible goal structures.

> Case 1: The POF's principal responsibility is for surge, meaning that the surge goal is greater than both the sustainment and peacetime goals.

In this case, the actives needed to meet the surge goal supply more than enough labor to meet the peacetime and sustainment goals as well. Consequently, the MAF equals the surge goal, and no additional manning is required. This would still be true if we minimized costs, so case 1 is a situation where a change in guidance would make no difference.

Case 2: The POF has heavy sustainment responsibilities but relatively small peacetime work loads. (The surge goal is smaller than the sustainment goal, and no larger than the peacetime goal.)

Now the active force necessary to satisfy the surge goal would also satisfy the peacetime goal, but additional manpower is needed for sustainment. Under our simplified assumptions, only actives or reserves can be used for sustainment, and both existing and cost-minimizing guidance would ask which category of military personnel costs less in that use. That depends on the number of reserves that one active could replace while maintaining sustainment capability and on the costs of actives and reserves.

Since drill reserves are paid much less than actives, using more actives than needed for surge can save costs only if each "extra" active can replace a fairly large number of reserves. Relative labor capabilities are not well measured in DoD data sources, are subject to debate, and probably vary from one defense activity to another. In this case, however, we know that if an extra active can replace enough reserves, even existing guidance would indicate that actives should be used, and the MAF would equal the sustainment (rather than the surge) goal. Consequently, if the POF would use reserves under existing guidance, extra actives are not cost-effective—and again the MAF and CAF rules would lead to the same manning configuration.

Case 3: The POF has heavy peacetime responsibilities but relatively small sustainment work loads (or the work loads can be met by wartime accessions from the civilian sector).

In this POF, the active force that satisfies surge also satisfies sustainment, but existing guidance would require using civilians (regardless of cost) to meet the remaining peacetime goal.

In contrast, the outcome under cost minimization takes account of civilian cost-effectiveness compared with actives. Making this comparison is difficult in practice because military and civilian personnel are designated by different job-grading systems. In certain professions, civilians may command a higher income than actives, and extra actives would save costs. In other occupations, however, actives receive costly defense training that civilians bring from the civilian sector, so civilians are less costly (to the DoD) and extra actives are not cost-effective. If we suppose that civilians are more cost-effective in the POF under analysis, then the CAF rule would once again lead to the same manning as the MAF rule.

Case 4:   The POF has heavy work loads in peacetime and sustainment, and surge is the smallest goal.

Finally, this POF needs more peacetime *and* sustainment labor than the actives used for surge can provide. Under the MAF rule, actives needed for surge would be supplemented by a combination of reserves and civilians. However, the CAF rule would replace that combination of reserves and civilians by using "extra" actives if they are more cost-effective. That depends on the relative wartime contributions of actives and reserves and the relative peacetime costs of actives and civilians—values we have described as especially uncertain. Below, however, we will argue that a wide range of those uncertain values would make extra actives cost-effective.

Suppose that extra actives are cost-effective. Then how many extra actives should be used under the CAF rule? If extra actives are only cost-effective when they replace a *combination* of reserves and civilians, then the POF should stop using extra actives when it runs out of reserves *or* civilians to replace. If the sustainment goal is greater than the peacetime goal, this will happen when the extra actives satisfy all of the peacetime goal; after that, additional actives can replace only reserves and are no longer cost-effective. Similarly, if the peacetime goal exceeds the sustainment goal, extra actives should be used only until the sustainment goal is reached.

GENERALIZED GUIDELINES

The preceding analysis for a single POF leads to basic findings that continue to apply even in our more complex models. One is that cost-minimization does not always lead to manning that is different from manning derived from existing guidance. Whether it does depends on the relative cost-effectiveness of actives, reserves, and civilians in each environment and on the POF's goal structure. In addition, case 4 shows that the number of extra actives that would save costs depends on which goal such actives would satisfy first.

Those findings set the stage for developing Cost-Effectiveness Criteria (CECs) that can be used to identify a cost-minimizing manning strategy for each POF. The three types of CECs are:

- Net Cost-Effectiveness (NCE) criteria: For each environment, the analysis estimates the costs or savings generated by using personnel in each category to replace personnel in each other category or combination of categories while continuing to meet the output goal in that environment. After all of the

computations are performed, the various combinations that save the most can be used to assign the POF in question to a cost category.

- Goal-structure criteria: The analysis evaluates the relative magnitudes of the POF's surge, sustainment, and peacetime goals. These computations allow the POF to be assigned to a goal-pattern category.
- Stopping rules: Another comparison among goals determines which one would determine the maximum number of extra actives that would be cost-effective. These computations assign the POF to a stopping-rule category.

Once the NCE, goal-structure, and stopping-rule categories are determined for a particular POF, standardized charts can be used to identify MAF- or CAF-recommended manning. We have developed general formulas for the CEC computations and used them to develop guideline charts for a much wider set of circumstances than those in the simplified analysis presented above. The only limitation on the guidelines development exercise is that it deals exclusively with single-POF cases.

The general analysis results in a larger number of cost categories and goal patterns than our simplified illustration suggests. Nonetheless, the number of required computations is not large, and standardized tables can still be used. Table 1 shows a possible display format for a guidelines table. NCE computations determine which of nine cost categories pertains to a POF, and goal-structure and stopping-rule computations together determine which of nine goal patterns pertains to the POF. The table indicates which of the 81 manning strategies is appropriate for the POF in question. In some cases, the table shows a line indicating that manning under the CAF rule would match manning under the MAF rule. In the remaining cases, the table indicates how actives beyond the MAF would be used to meet the POF's goals. Guidelines documentation in support of Table 1 would explain how each of the cost and goal pattern categories is defined.

Table 1

ILLUSTRATIVE GUIDELINES TABLE FOR CAF-RECOMMENDED MANNING, BY COST CATEGORY AND GOAL PATTERN

Cost Category	Goal Pattern								
	1a	1b	2a	2b	2c	3a	3b	4	5
1	—	—	—	—	—	—	—	—	—
2	—	—	—	—	—	A	A	B	—
3	—	—	—	C	D	C	D	B	—
4	—	—	—	—	—	A	A	D	D
5	—	—	—	C	D	C	D	D	D
6	—	E	—	C	E	C	E	E	E
7	—	—	E	E	D	E	D	B	—
8	—	—	E	E	D	E	D	D	D
9	—	E	E	E	E	E	E	E	E

KEY: A = extra actives with crossflows for sustainment, plus civilians for peacetime.

B = extra actives with crossflows for peacetime, plus nonprior-service reserves for sustainment.

C = extra actives without crossflows for sustainment, plus civilians for peacetime.

D = extra actives with crossflows for all environments.

E = extra actives without crossflows for all environments.

V. DUAL-USE MODEL FINDINGS

In practice, labor supplies to individual POFs are not managed independently. Programs exist that retrain and reassign personnel from one activity to another, that rotate personnel among activities in different locations, and that use personnel to perform peacetime jobs different from wartime assignments.

TFM "dual use" models explicitly portray the way these programs redistribute labor contributions to different activities in different environments.[1] The models show that these programs provide additional opportunities to make cost-effective use of extra actives. Beyond that, however, the analysis suggests that TFM models can be used to gain important insight into how to manage these programs more cost-effectively.

We modeled several different hypothetical dual-use program designs. For each design, we modeled the way the program would affect several alternative pairs of POFs distinguished by their goal structures. This procedure yielded a large number of cases from which we could discern general patterns of cost behavior.

In addition, we used the dual use models to investigate the implications of civilian availability for wartime work. Whenever using civilians costs less than using equally qualified active personnel, a single-POF model always uses civilians instead of actives to do any work for which civilians are available. Some observers have inferred that TFM models only recommend using extra actives because the models assume civilians cannot do wartime work. The dual use models show that using extra actives can save costs even in POFs that are nondeployable and can use civilians in wartime.

MOBILIZATION PROGRAMS

We have considered three alternative mobilization program designs. In all cases, senior actives perform a different peacetime job

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[1]Expanding the single-POF model to deal with two POFs is straightforward. First, a second set of parameter values pertaining to the second POF is specified. Second, constraints identical to those for a single POF are added to ensure that all defense output goals are met in the second POF. Third, the objective function is revised to apply to the sum of outcomes in the two POFs. Under the MAF rule, the primary objective becomes minimization of military personnel costs summed over the two POFs; under the CAF rule, the objective is to minimize the sum of all personnel costs. The same basic procedure can also be used to expand the model to many POFs, though our current analyses use only two.

than they would in wartime. In the first alternative (Mobilization 1), senior actives remain in their initial POF during peacetime but mobilize with a different POF during wartime. This formulation might be used when the second POF has a vastly increased wartime work load, such as security for facilities or weapons installations. Alternatively, Mobilization 2 reassigns senior actives to a second POF for peacetime work but would mobilize them with their initial POF. An obvious example would be pilots who, after some years of initial operational experience, take on peacetime management and administrative duties. Finally, Mobilization 3 is like Mobilization 1 but applies the program to senior reserves as well.

All of the mobilization programs are optional in our analysis: They are used under the MAF objective only if they reduce military costs, and they are used under the CAF objective only if they reduce total personnel costs. Our illustrative analyses also impose a bias against using the programs by assuming that program participants would be in transit during surge and hence could not contribute to any surge output. Not surprisingly, none of the programs save costs under the MAF rule.

However, mobilization programs save costs for some combinations of POFs under the CAF rule. The analysis suggests that even if mobilization programs detract from active availability for surge, the programs can save money if the pair of POFs involved is properly selected. And TFM modeling can help select those combinations.

Perhaps more important, we observed that costs could be saved under the CAF rule even when the CAF and MAF rules agreed on how to man each of the POFs separately. In one such example, pairing the POFs under the mobilization program reduced personnel costs by 13 percent. The implication is that *the cost-saving potential of cost-minimization guidance may be vastly understated by analyses that ignore dual use programs.*

In POF pairs where mobilization programs could save money, they reduced total personnel inventories compared with the MAF rule: The number of actives increased less than the decline in the combined number of reserves ar $ civilians.

Although MAF manning (without mobilization) and CAF manning (with mobilization) necessarily meet the goals in both POFs, the mix of potential capabilities beyond the goals differs. Inflexibilities owing to limited lateral entry to the DoD work force imply that manpower sufficient to meet all goals usually provides excess capability in some environments under either rule. However, the cases we examined show that the MAF rule often generates excess peacetime capability, whereas the CAF rule often generates excess wartime capability. The

implication is that, with mobilization programs, the CAF rule can save money and can also generate a more capable warfighting force.

RETRAINING PROGRAMS

We modeled two retraining programs. In the first program, senior actives are retrained and then permanently assigned to a different POF for both peacetime and wartime work. The second program also retrains senior reserves.[2] As with the mobilizational programs, the retraining programs are optional.

The retraining analysis used two alternative sets of parameters; one assumes that junior personnel are not available for wartime work, and a second more realistically provides for junior wartime contributions. Analyses using all the POF pairs we studied indicate that the retraining program would never be used when juniors can do wartime work. Under the first parameter set, however, retraining took advantage of junior, active, peacetime labor in POFs with high peacetime work loads, then reassigned this labor as seniors to POFs with high wartime work loads. Given significant retraining costs, it costs less to keep personnel in the same POF, where they contribute to all capabilities throughout their careers, than to reassign them among POFs.

If retraining were far less expensive than indicated by the estimates we use, it might be employed more commonly to help match personnel capabilities with POF goals. Indeed, other analyses based on simpler versions of our TFM model show a clear relationship between the magnitude of retraining costs and the number and types of POF pairs for which retraining saves costs.

ROTATION PROGRAMS

Unlike the other dual use programs, the rotation programs are not optional, and the rotation models are also asymmetric: In each pair of POFs, personnel in just one of the POFs must rotate.

In most cases, the mandatory rotation programs raise total costs under the MAF rule—but there is an exception. In that case, the program actually reduces costs (slightly) compared with the results of not invoking the program. The reason is that rotation requires an in-

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[2]In practice, reserve retraining can play a special role in helping to match the skills of personnel located near a reserve installation to its needs. Our model is not currently designed to address that issue fully. However, the reserve retraining issue clearly could be analyzed by means of the multi-POF modeling approach.

creased number of active personnel to pass through a POF where those additional actives happen to be cost-effective. These same findings are repeated under the CAF rule: Mandatory rotation generally increases costs relative to no dual use but can save money in cases where the joint management of two complementary POFs improves efficiency in manpower use.

These comparisons between no dual use and rotation are suspect because we have not accounted for the potential retention effects of keeping personnel continuously in their overseas or shipboard assignments. TFM models could be used to investigate the implications of retention effects and could even help evaluate rotation program design questions (such as whether the differing retention effects of alternative tour lengths make some more cost-effective than others), but such analysis would require retention-behavior evidence we did not collect for this study.

Without allowing for retention effects, the models are better suited to addressing a different rotation issue: Given that personnel in a particular POF will rotate, which other POF should be their CONUS (Continental United States) assignment? An illustrative case shows that this type of analysis can be instructive: For one of our rotation program designs, existing guidance and cost-minimization would result in different CONUS locations for pairing with the same non-CONUS POF. Furthermore, even when the two principles would recommend the same pairing, the amount of savings from choosing the "preferred" POF differed considerably, with much more savings potential from making the "right" choice under existing guidance.

Although a single illustrative analysis cannot support much generalization, it seems likely that the cost differences among POF pairings are often larger under existing guidance than under cost-minimization. The MAF rule does not exploit all potential cost-savings for any given pairing, and hence costs are likely to be especially sensitive to the pairing that is chosen. In any case, the illustration suggests that using TFM models to assess rotation alternatives could be quite fruitful even if existing guidance did not change.

SPECIAL CASES: WHEN CIVILIANS ARE AVAILABLE IN WARTIME

In all analyses to this point, civilian availability for wartime (surge and sustainment) was assumed to equal zero. Some observers of the TFM research have inferred that extra actives could not be justified—even under a CAF rule—if civilians were available for wartime work.

That inference is not necessarily correct under dual use conditions. When it is possible to use actives to man deployable activities in wartime and nondeployable activitie in peacetime, it might be cost-effective to use actives rather than civilians in the latter activities. Furthermore, actives are far more readily reassigned among defense activities in different locations. Even if civilians are fully available in each of two POFs that could be paired under dual use, the two POFs might have to be manned independently if civilians are used, and potential dual-use efficiencies would not be available.

To study these factors, we modeled pairings between a POF that could use civilians in all environments and a POF that required military personnel in wartime. We considered a mobilization program that allows actives (but not civilians) to be reassigned from one POF to another during wartime. We also considered rotation programs that required actives (or actives and reserves) to rotate between the two POFs.

Results for the mobilization program showed that the inability to reassign civilians imposes inefficiencies that can be overcome by using the same actives in both POFs. The MAF rule would not use the program and would rely heavily on civilians in both POFs. In contrast, the CAF rule would use the mobilization program to reduce the civilian work force and cut total costs.

Since rotation programs are mandatory, the relevant question is, would managing rotation under a CAF rule use extra actives that would not be used under the MAF rule? We already saw that the answer could be yes even when civilians are not available for wɛ ime work in either POF. The special cases also show that the answer could be yes even when civilians are fully available in wartime in the (presumably nondeployable) POF to which military personnel rotate from their overseas or shipboard assignments. In nearly every case we considered, the CAF rule saved significant amounts of money by altering the manning mix for a given rotation.

When the CAF rule saves money, the resulting personnel mix reflects a particular combination of two distinct factors:

1. Additional rotating actives can replace a combination of reserves in the deployable POF and civilians in the nondeployable POF.
2. Reserves replace civilians in supporting wartime sustainment in the *nondeployable* POF.

On the whole, the results suggest that manning under the MAF rule would lead to excessively costly reliance on civilians in the CONUS-based POFs that support the rotation base. This analytical

result tallies with observations by military personnel managers, who find that efforts to civilianize nondeployable defense activities often (1) pose problems for maintaining the rotation base and (2) lead to costs that were not foreseen in the single-activity cost assessment done to evaluate the decision to civilianize.

The bottom line is that civilian nonavailability for wartime is *not* the key reason why the CAF rule tends to use a larger active force than the MAF rule does. When labor supplies to POFs interact through dual use programs, the fact that civilians are available for wartime in one or both POFs does not prevent the use of extra actives from saving costs.

DUAL-USE PROGRAMS: A CONCEPTUAL APPRAISAL

The most obvious common feature among dual use programs is that they allow POFs to "share" the capabilities generated by active (and sometimes reserve) life cycles. Consequently, the programs should hold some promise of improving military personnel cost-effectiveness by achieving a better match between capabilities and goals. Whether that potential is achieved in practice depends, however, on how the programs are implemented—and it is in this reg .d that each program's unique features play a special role.

Consider, first, the mobilization programs: As we modeled them, they not only redistribute capabilities among POFs but also introduce barriers to the full use of surge capabilities. This feature tends to increase the required force sizes and costs for defense as a whole (i.e., for the aggregate of all defense POFs). Whether, on balance, mobilization programs save money and manpower resources depends on whether the savings from improved allocation of personnel capabilities outweigh cost increases to achieve aggregate surge capabilities.

Rotation programs are conceptually similar to mobilization programs because peacetime manpower in one POF becomes available to another POF in both cases. The essential difference is that mobilization progr   our models are used only if they help minimize costs, whereas rotation is mandatory. Therefore, rotation programs should be able to save money if their division of capabilities between POFs is sufficiently similar to what would happen under optimal mobilization programs. Indeed, we observed a case in which a rotation program saved money relative to the MAF rule without dual use.

Since the retraining programs "permanently" reassign personnel, they do not suffer the loss in surge capability that can prevent the other programs from saving money. Therefore, if retraining programs do not indirectly affect personnel retention or morale and can result

in the same job qualification levels held by personnel who are not re-trained—all of which is assumed in our models—retraining holds considerable promise for potential savings. However, as this section shows, this potential depends critically on whether important differences exist between the capabilities of junior and senior personnel.

Under all programs, however, the existence and magnitude of retraining costs constitute an important determinant of the outcomes. Presumably, some of the programs we examined would save costs if retraining costs are low or would stop saving costs if retraining costs are high.

Furthermore, the choice of POF "pairs" is critical to cost-effectiveness. Programs that are exceedingly cost-effective for one pair of POFs may offer no savings (and in the case of rotation programs can even increase costs) when applied to a different pair of POFs.

Dual use models show that such programs can have far-reaching significance for evaluating manning options. Conclusions reached by examining only a single defense activity can be quite different from those that take account of manpower interactions with other activities. Indeed, our results provide an analytic explanation for a commonly encountered difficulty in actual manpower management: Throughout the Defense Department, activities have been and are being civilianized on the presumption that civilian manning is more cost-effective—and then personnel managers must cope with difficulties in finding peacetime assignments for essential military personnel. We infer that these difficulties are not merely a consequence of attempts to cut defense spending but may result from incorrect savings estimates for civilianizing efforts.

VI. CAN COST-EFFECTIVENESS GUIDELINES WORK?

In a single POF analysis, the conditions that would lead to using extra actives under a cost-minimization rule appear restrictive, because extra actives can be cost-effective only if they substitute for a combination of reserves and civilians within a single POF. Since relatively few examples of individual defense activities use a combination of actives, reserves, and civilians under existing guidance, it is tempting to conclude that cost-minimization could not have large effects on total defense manning.

For this reason, addressing multiple POFs in dual use combinations is a significant extension of TFM modeling. As illustrated above, such models show that extra actives might be cost-effective even if *no* defense activities existed that use all three types of manpower. Instead, replacement opportunities arise from combining POFs that use different manpower mixes.

The DoD as a whole uses large numbers of actives, reserves, and civilians; there is considerable overlap in their occupational categories; and existing retraining, mobilization, and rotation programs already provide mechanisms for dual use. Hence, numerous opportunities might well exist to save money by using extra actives to provide a suitable combination of wartime and peacetime work.

If so, the next question is whether that substitution would be cost-effective. Among the determining variables, especially uncertain ones are the comparative labor contributions of actives and reserves and the comparative costs of equally capable civilians and actives. However, Fig. 1, which is based on actual DoD data for fiscal year 1986,[1] suggests that a wide range of those uncertain values exists for which the substitution would save costs.

Each point in the figure represents a particular combination of the uncertain values of reserve-active contribution rates and active-civilian pay. The curve in the upper right indicates parameter combinations for which cost effects are exactly zero when an extra active replaces a combination of actives and reserves within a single POF,

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[1] The figure is based on the following estimates: average annual cost, actives, $30,746; average annual cost, reserves, $8,226; annualized training cost, $5,099; ratio of reserve-to-active pay, 0.27; ratio of training cost to active pay, 0.17. All personnel are assumed to require training for the calculations in the figure; the indicated active-to-civilian pay ratios exclude the training costs.
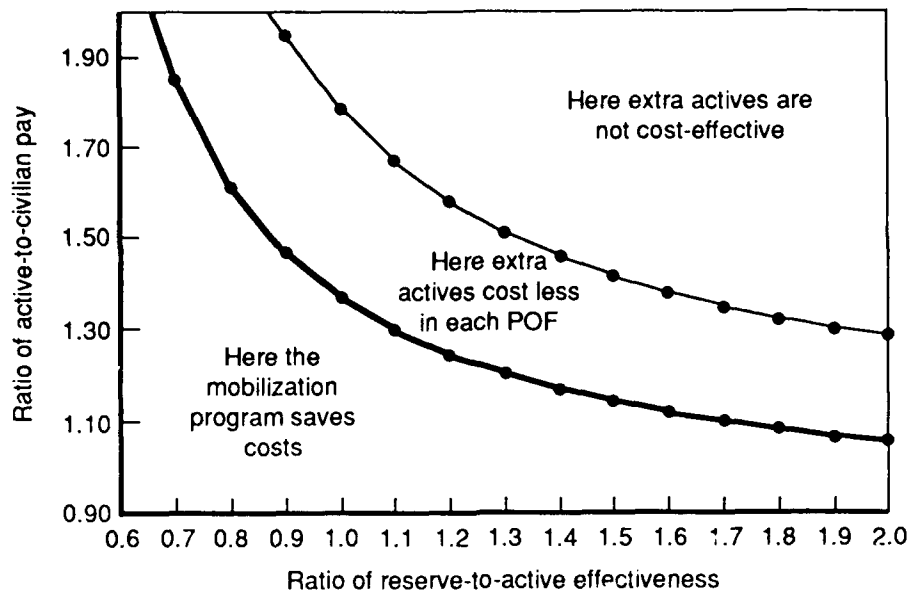
Fig. 1—Ranges of cost and effectiveness ratios that make extra
actives cost-effective

holding output in all environments constant; when the combination of
uncertain values lies above that curve, it does not save costs to add
extra actives. The lower curve corresponds to a zero cost effect when
the replacement occurs for a pair of POFs under a mobilization pro-
gram (assuming that a pair of POFs has the same values for all other
parameters); below that curve, it saves costs to implement the mobi-
lization option. Between the two curves, extra actives are cost-effec-
tive in each of the POFs when they are managed separately.

The figure suggests that a very wide range of contribution and pay
ratios would make CAF greater than MAF. For example, Palmer and
Rydell (1989) used an average annual civilian cost of $29,652, yield-
ing an active-to-civilian pay ratio of 1.04. If that ratio applied to
equally productive workers, extra actives would be cost-effective (in
both individual POF management and under a mobilization program)
if reserves are as little as half as effective—or as much as twice as ef-
fective—as actives.

When cost-minimization differs from existing guidance, the savings
from expanding the active force depend on the NCE per extra active
and the number of extra actives. Continuing the preceding example,
if the active-to-civilian pay ratio were 1.04 and the reserve-to-active
contribution ratio were 0.8, the savings per extra active would be
$15,423—and adding as few as 5,000 extra actives throughout the

DoD would save over $70 million. In short, the savings from even modest improvements in cost-effective manning could be substantial.

VII. PARAMETER-VALUE UNCERTAINTY

It is widely recognized that defense-labor effectiveness is difficult to assess because wartime performance is not directly observable. This fact has generated debate between decisionmakers who favor objective (even if imperfect) performance measurement and those who believe professional judgment is a more reliable guide for decisionmaking. In light of this concern, we performed some sensitivity analyses to determine how alternative effectiveness parameter values would influence the manning strategy selected under a cost-minimization rule.

As Fig. 1 (above) suggests, uncertainties about the active-to-civilian pay ratio and (especially) the reserve-to-active effectiveness ratio may not be pivotal in decisions about whether extra actives can be cost-effective. The general observation is that there are usually several combinations of the uncertain parameters that would place a POF in the same cost category, and there are usually several cost categories that would lead to the same CAF manning guidelines for a POF with a particular goal pattern. Consequently, *precise, accurate measures of active-to-civilian pay ratios and relative reserve effectiveness are not always needed to select a cost-minimizing manning strategy.* In an era when performance measurement efforts are expanding, costly efforts to reconcile differences between professional assessments and performance testing might best focus on those cases where the two measures could lead to important differences in manning strategy.

Clearly defined critical values for various parameters are, of course, a property of the linear programming (LP) analysis method. That method approximates relationships that are often nonlinear and stochastic by means of deterministic, linear equations. Consequently, the critical values generated by an LP analysis are themselves uncertain and imprecise.

However, the use of linear approximations is extremely widespread in defense cost assessments and management analyses and is not found solely in the TFM models we have been developing. What distinguishes these models is that they incorporate many features of personnel and manpower management that are not often found in DoD quantitative studies.

VIII. CONCLUDING REMARKS

Traditionally, two very different types of modeling approaches are used in addressing manpower and personnel decisions. One type of model focuses on the force element—a type of squadron or wing, a type of battalion or division, a class of ship, etc.—as the unit of analysis. This type of analysis is used to make long-range decisions about overall force structures, including decisions about whether to assign certain types of missions to active or reserve forces. A specific manning profile (including actives, reserves, and civilians by occupation and perhaps grade) is directly associated with the force unit, and although that profile may be designed with due attention to sustaining the profile over time (e.g., to providing a maintainable mix of junior and senior personnel), the models do not explicitly address the personnel management actions needed to supply the desired personnel on a continuing basis. In effect, force-unit modeling deals with the "spaces" to be filled rather than the challenge of finding the "faces" to fill them.

In contrast, a second type of model focuses explicitly on dynamic flows through personnel inventories. These models trace out the year-by-year effects of changes in personnel management actions (e.g., accessions, retention bonuses) and to some extent allow analysts to devise management activities that can meet size, structure, or cost targets for the inventory as a whole. These personnel management models do not deal with mixes of active, reserve, and civilian personnel but analyze a single type of personnel exclusively.

A primary objective of our TFM modeling is to provide explicit linkages between these two types of models and the types of decisions they support. Achieving that objective inevitably leads to hybridized modeling designs that appear unfamiliar in both decision contexts.

Our TFM designs focus attention on accession and retention actions and in that respect address the concerns of personnel management models. However, these TFM designs set objectives for personnel management based on sustainable capability goals, much as force-unit models do. This type of design is especially appropriate for developing general, long-term guidelines for personnel management and for conducting exploratory studies to learn how various personnel management programs influence defense capabilities and costs. In short, this type of TFM design is well-suited to the applications developed here.

However, these designs are less suited to addressing decisions about force structure development and choices concerning the active-reserve balance of forces. For those applications, a different type of design appears promising. It would treat the principal decisions as involving the choices among alternative combinations of force structure units, including alternatives for manning units to perform the same general type of mission or function. It would use the properties of dynamic personnel-inventory management to assess the feasibility and costs of supplying the work forces consistent with activating, sustaining, and deactivating force units over time. The result would still be a hybrid of force-unit and personnel management models, but the designation of management actions, objectives, and constraints would be different from the designations in the TFM models.

We believe that such TFM models are now feasible and desirable as aids to defense decisionmaking. The TFM analyses conducted so far have established some general insights into how various features of personnel management affect the costs of filling manpower spaces. The next logical step, in our view, is to use those insights to improve the DoD's ability to develop force structures that meet changing threats effectively in a era of declining resources and reduced troop strengths.

BIBLIOGRAPHY

Binkin, M., *Military Technology and Defense Manpower*, esp. Chap. 4, "Implications for Manpower Requirements," The Brookings Institution, Washington, D.C., 1986.

Comptroller General's Report to the Congress, *DoD "Total Force Management"—Fact or Rhetoric?* U.S. General Accounting Office, FPDC-78-82, January 1979.

Department of Defense, *National Defense Budget Estimates for FY 1987*, Office of the Assistant Secretary of Defense (Comptroller), Washington, D.C., May 1986.

Department of Defense, *Manpower Requirements Report for FY87, Vol. III, Force Readiness Report*, Office of the Assistant Secretary of Defense (Force Management and Personnel), Washington, D.C., 1987.

Hosek, S., et al., *Reconciling Air Force Physicians' Peacetime and Wartime Capabilities: Demonstration of a Workforce Design Methodology*, The RAND Corporation, R-3202-AF, August 1985.

Jaquette, D. L., and G. R. Nelson, *The Implications of Manpower Supply and Productivity for the Pay and Composition of the Military Force: An Optimization Model*, The RAND Corporation, R-1451-ARPA, July 1974.

Jaquette, D. L., G. R. Nelson, and R. J. Smith, *An Analytic Review of Personnel Models in the Department of Defense*, The RAND Corporation, R-1920-ARPA, September 1977.

Palmer, A. R., and D. J. Osbaldeston, *Incremental Costs of Military and Civilian Manpower in the Military Services*, The RAND Corporation, N-2677-FMP, July 1988.

Palmer, A. R., and C. P. Rydell, *An Integrative Modeling Approach for Managing the Total Defense Labor Force*, The RAND Corporation, R-3756-OSD/AF, December 1989.

Rydell, C. P., A. R. Palmer, and D. J. Osbaldeston, *Developing Cost-Effectiveness Guidelines for Managing Personnel Resources in a Total Force Context*, The RAND Corporation, R-4005/1-FMP, 1991.